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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Neil G. Murray Jr. et al.
Serial No. : 10/767,798
Filing Date : January 29, 2004
For : METHOD FOR MONITORING
QUALITY OF A TRANSMISSIVE
LASER WELD
Group Art Unit : 2859
Examiner : G. K. Verbitsky
Attorney Docket No. : TRW(TE)6888

Mail Stop Appeal Brief - Patents

Commissioner for Patents
P.O. Box 1450
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APPEAL BRIEF

Sir:

Following the Notice of Appeal filed July 7, 2008, Appellants present this
Appeal Brief.

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I. REAL PARTY IN INTEREST

The real party in interest is TRW Automotive U.S. LLC. An assignment of this application to TRW Automotive U.S. LLC was recorded January 29, 2004, Reel/Frame: 014951/0908.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences.

III. STATUS OF CLAIMS

Claims 1-8, 12-21 and 24-36 are currently pending in this application. Claims 1-4, 13-15, 20-21, 25-26 and 29-30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 7,268,866 to Messler (hereafter "Messler") in view of U.S. Patent No. 6,177,649 to Juret et al. (hereafter "Juret"). Claim 12 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Messler and Juret in view of U.S. Patent No. 4,083,223 to Hashimoto et al. (hereafter "Hashimoto"). Claims 7 and 18 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Messler and Juret in view of U.S. Patent Appln. Publication No. 2002/01724410 to Shepard (hereafter "Shepard"). Claims 8 and 19 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Messler, Juret and Shepard in view of U.S. Patent No. 4,214,264 to Traub et al. (hereafter "Traub"). Claims 24 and 28 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Messler and Juret in view of U.S. Patent No. 6,299,346 to Ish-Shalom et al. (hereafter "Ish-Shalom"). Claims 5-6, 16-17 and 31-34 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Messler and Juret in view of Shepard. Claim 27 stands rejected under 35 U.S.C. §103(a) as being unpatentable over Messler and Juret in view of

U.S. Patent No. 7,044,634 to Sandvoss (hereafter "Sandvoss"). Claims 35-36 stand rejected without a reference to prior art or rationale of any kind. The rejections of claims 1-8, 12-21 and 24-36 are appealed.

IV. STATUS OF AMENDMENTS

A Response After Final Rejection was filed July 11, 2008. No amendments to the claims have been filed after the Final Office Action of April 11, 2008. An Advisory Action dated July 29, 2008 indicated that the Response After Final Rejection was not entered and the rejection of claims 1-8, 12-21 and 24-36 was maintained.

V. SUMMARY OF THE INVENTION

Independent claim 1 recites a method for welding and monitoring the quality of a laser weld (56) being formed between first and second pieces (10, 12) of plastic material (Fig. 1). The first and second pieces (10, 12) are positioned to abut each other (Fig. 1), the second plastic piece (12) being transmissive to a laser beam (50) (Page 7, lines 10-16 and Fig. 1). The first and second pieces (10, 12) are heated at their location of abutment by directing the laser beam (50) to form a pool of material (60) at the location of abutment which pool of material (60) forms a weld (56) between the pieces (10, 12) (Page 10, lines 8-22). Simultaneous with said heating step, a thermal image is obtained as the weld (56) is being formed by collecting infrared radiation passing through the second piece (12) of material from the weld (56) and the pool of material (60) (Page 12, lines 5-13 and Figs. 1-2). The obtained thermal image is analyzed for characteristics indicative of an acceptable weld being formed (Page 15, lines 13-24). A feedback signal is provided to a weld controller

(46) in response to determining that a characteristic fails to meet an associated criterion (Page 16, lines 7-15). The heating is modified in response to the feedback signal (Page 17, lines 14-22).

Independent claim 13 recites a method for welding and monitoring the quality of a laser weld (56) being formed between first and second pieces (10, 12) of plastic material (Fig. 1). The first and second pieces (10, 12) are positioned to abut each other (Fig. 1), the second plastic piece (12) being transmissive to a laser beam (50) (Page 7, lines 10-16 and Fig. 1). The first and second pieces (10, 12) are heated at their location of abutment by directing the laser beam (50) to form a pool of material (60) at the location of abutment which pool of material (60) forms a weld (56) between the pieces (10, 12) (Page 10, lines 8-22). A range of wavelengths of infrared radiation is determined that will pass through the second piece (12) of material (Page 6, lines 14-24). An infrared detector (70) that is configured to detect infrared radiation within the determined range of wavelengths is positioned on a side of the second piece (12) of material opposite the first piece (10) of material (Page 11, lines 20-24 and Fig. 1). Simultaneous with said heating step, a thermal image is obtained as the weld (56) is being formed between the first and second pieces (10, 12) of material by collecting infrared radiation within the determined range of wavelengths and from the weld (56) and the pool of material (60). The obtained thermal image is analyzed for characteristics indicative of an acceptable weld being formed (Page 15, lines 13-24).

VI. GROUND OF REJECTION TO BE REVIEWED ON APPEAL

- a. Whether claims 1-4, 13-15, 20-21, 25-26 and 29-30 are unpatentable under 35 U.S.C. §103(a) as being obvious over Messler in view of Juret.
- b. Whether claim 12 is unpatentable under 35 U.S.C. §103(a) as being obvious over Messler and Juret in view of Hashimoto.
- c. Whether claims 7 and 18 are unpatentable under 35 U.S.C. §103(a) as being obvious over Messler and Juret in view of Shepard.
- d. Whether claims 8 and 19 are unpatentable under 35 U.S.C. §103(a) as being obvious over Messler, Juret and Shepard in view of Traub.
- e. Whether claims 24 and 28 are unpatentable under 35 U.S.C. §103(a) as being obvious over Messler and Juret in view of Ish-Shalom.
- f. Whether claims 5-6, 16-17 and 31-34 are unpatentable under 35 U.S.C. §103(a) as being obvious over Messler and Juret in view of Shepard.
- g. Whether claim 27 is unpatentable under 35 U.S.C. §103(a) as being obvious over Messler and Juret in view of Sandvoss.
- h. Whether claims 35-36 are unpatentable.

VII. ARGUMENTS

To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

Claim 1

The combination of Messler and Juret does not teach or suggest all the limitations of claim 1.

Claim 1 recites the step of obtaining a thermal image as a weld is being formed by collecting infrared radiation passing through a second piece of material from the weld and a pool of material.

Messler teaches that a pyrometer 58 detects the thermal radiation 60 emitted by the weld at the melt 48, i.e. the unsolidified portion of the weld seam 15 (Fig. 6). The solidified weld seam 15 is inspected by inspection radiation 30, whose exit radiation 33, 33' from an inspection point 57 on the weld 15 is detected by a detector 55 (Col. 7, lines 1-3 and Fig. 2). The inspection point 57 is located at a well-defined distance 51 from the focus 47 of the heating laser beam 20, which is the area in which the melt 48 forms between the materials 18, 19 (Col. 6, lines 26-30 and 35-36). The inspection radiation 30 is completely independent of the thermal radiation emanating from the weld (Col. 5, lines 36-38).

The Examiner asserts that, although the inspection radiation 30 and the pyrometer 58 are completely independent, they can be used simultaneously during the welding as well as on the finished product (see Advisory Action). The Applicant, however, is not asserting that the inspection radiation 30 and pyrometer 58 are completely independent in a temporal sense, as Fig. 6 clearly illustrates

simultaneous use. Rather, it is asserted that the inspection radiation 30 and pyrometer 58 are completely independent in a functional sense. In particular, it is clear from the above that the inspection radiation 30 inspects only the solidified weld seam 15 and the pyrometer 58 inspects only the unsolidified melt 48. This is the case whether the inspection occurs during welding, as noted, or at a time following welding in which only the weld seam 15 exists and, only inspection radiation 30, such as the last radiation 20, is used (Col. 5, line 64 – Col. 6, line 2). Accordingly, Messler does not teach obtaining a thermal image as a weld is being formed by collecting infrared radiation passing through a second piece of material from the weld and a pool of material.

Juret does not cure the deficiencies of Messler. Juret is related to an IR camera 6 that is designed to provide thermal images of certain locations in relation to the fusion zone of two metal plates being welded together end-to-end. The Examiner asserts (Office Action page 9) that Juret teaches that it is very well known in the art to use an IR camera to indicate a thermal profile of a weld prior, during and after welding (Col. 1, lines 24-31). This profile, however, is not directed at a weld and a pool of material. Rather, an IR camera 6 may observe a zone disposed immediately ahead of the advancing fusion zone, or a zone providing a thermal image at the fused metal, or a zone behind the advancing fusion zone (Col. 5, lines 6-13 and Fig. 2A). None of these zones capture thermal images of a weld and a pool of material, as recited in claim 1. Thus, Juret does not cure the deficiencies of Messler. Since the combination of Messler and Juret does not teach the subject

matter of claim 1, it is respectfully submitted that claim 1 is patentable over the combination of Messler and Juret and is therefore allowable.

Claims 12 and 26-32 depend from claim 1 and are allowable for at least the same reasons as claim 1 and for the specific limitations recited therein.

Claim 2

The combination of Messler and Juret does not teach or suggest all the limitations of claim 2.

Claim 2 recites the step of obtaining a thermal image that includes, in its entirety, a weld pool that results in a weld. Neither Messler nor Juret taken either alone or in combination disclose or suggest this feature. In Messler, the pyrometer 58 detects only the thermal radiation of a portion of the melt 48 and not an entire weld pool that results in a weld.

Juret does not cure the deficiencies of Messler. As noted, the profile of the IR camera 6 in Juret includes only the fused metal and is not configured to have a field of view which includes an entire weld pool. Thus, Juret does not teach obtaining a thermal image that includes, in its entirety, a weld pool that results in a weld. Since the combination of Messler and Juret does not teach the subject matter of claim 2, it is respectfully submitted that claim 2 is patentable over the combination of Messler and Juret and is therefore allowable.

Claims 4-8 depend from claim 2 and are allowable for at least the same reasons as claim 2 and for the specific limitations recited therein.

Claim 3

The combination of Messler and Juret does not teach or suggest all the limitations of claim 3.

Claim 3 recites the step of positioning an infrared detector in a location in which a weld pool in its entirety is within a field of view of the infrared detector. As noted, the combination of Messler and Juret does not teach imaging a weld pool in its entirety. Thus, the combination of Messler and Juret does not teach positioning an infrared detector in a location in which a weld pool in its entirety is within a field of view of an infrared detector. Since the combination of Messler and Juret does not teach the subject matter of claim 3, it is respectfully submitted that claim 3 is patentable over the combination of Messler and Juret and is therefore allowable.

Claim 25

The combination of Messler and Juret does not teach or suggest all the limitations of claim 25 because the step of directing the laser beam over the path of a weld pool multiple times is not equivalent to a plurality of short point applications of a laser beam along a path.

Claim 25 recites the step of heating the first and second pieces at their location of abutment to form a pool of material at the location of abutment which pool of material forms a weld between the pieces is performed by directing the laser beam over the path of the weld pool multiple times. Modifying occurs during directing of the laser beam over the path during at least one of said multiple times. Neither Messler nor Juret disclose or suggest this feature.

The Examiner asserts that Messler teaches a laser beam in a continuous mode and that this mode, in its broadest reasonable interpretation, constitutes a plurality of short point applications of the laser beam equivalent to heating the

abutment, i.e. path, multiple times (see Advisory Action). Claim 13 does not recite that the plastic parts are heated by the laser beam by a plurality of point applications. Rather, claim 13 specifically recites directing the laser beam over the path of a weld pool multiple times. This recitation is clearly supported in the specification. In particular, it is disclosed that the beam 50 of electromagnetic energy may start in the upper, right corner of the weld pool 60 (Fig. 2) and may be moved around the generally square-shaped path in a clockwise direction multiple times (Page 11, lines 5-9). Thus, the beam 50 is directed over the same points on the path multiple times. This beam directing is not equivalent to a plurality of short applications of a beam, as the Examiner asserts.

In fact, Messler specifically teaches not directing the laser beam over the path of a weld pool multiple times. In particular, Messler specifically discloses that for the first method of Fig. 2, a laser beam 20 strikes two movable beam-deflecting mirrors 23, 24, which direct the laser beam to the workpiece 10 through a theta objective 35 to produce the weld seam 15 by simultaneous welding (Col. 4, lines 9-16). Messler specifically discloses that the laser beam 20 enters a processing head 50 and is collimated by a lens 45 in the method of Fig. 6. The beam then passes through two mirrors 43, 44 and is bundled by a collimator 46 and focused on a well-defined area 47 of the workpiece 10 (Col. 6, lines 14-17). A melt 48 of both materials 18, 19 forms in the area of the focus 47. During movement of the workpiece 10 relative to the processing head 50, the focus moves along the workpiece, and the melt gradually undergoes solidification 49. The weld seam 15 forms in this way (Col. 6, lines 26-31). Thus, the laser beam is directed over the path, where the weld seam is

formed, only once and not multiple times. The head 50 does not, for example, return to the start of the weld 15 and re-trace the same weld path to form the weld 15. Accordingly, Messler does not teach or suggest directing a laser beam over the path of a weld pool multiple times.

Juret discloses a high energy-density beam 4 from a beam generator that welds two metal plates at their joint. The beam-generator 3 is fixed to a frame member 5 that is displaceable in the direction of the plane of the joint of the metal plates 1, 2 being welded. Juret discloses that the frame member 5 moves from left to right during welding of the plates. Juret fails to disclose or suggest directing the beam 4 over a path of a weld pool multiple times and, thus, does not cure the deficiencies of Messler. Since the combination of Messler and Juret does not teach the subject matter of claim 25 it is respectfully submitted that claim 25 is patentable over the combination of Messler and Juret and is therefore allowable.

Claim 33

The combination of Messler and Juret does not teach or suggest all the limitations of claim 33, and Shepard does not cure the deficiencies of Messler and Juret because the step of stopping the obtaining of any thermal images of a formed sample is not “necessarily present” in Shepard.

Claim 33 recites the step of obtaining a plurality of thermal images as the weld is being formed and stopping the obtaining of any thermal images of the weld after the weld is formed. The Examiner acknowledges that Messler and Juret do not teach obtaining a plurality of images and stopping the obtaining of any thermal images of a weld after the weld is formed. The Examiner asserts, however, that Shepard cures the deficiencies of Messler and Juret.

Shepard does not disclose stopping the obtaining of thermal images of the weld after the weld is formed. The Examiner argues that it is inherent that "Shepard would not take any images after the full image is reconstructed, and there is no need to take more images".

Under the doctrine of inherency, if an element is not expressly disclosed in a prior art reference, the reference will still be deemed to include the missing element if the missing element is "necessarily present" in the item described in the reference.

Continental Can Co. v. Monsanto Co., 948 F.2d 1264, 1268 (Fed. Cir. 1991).

"Necessarily present" for inherency means more than merely probably or possibly present. Trintec Industries, Inc. v. Top-U.S.A. Corp., 295 F.3d 1292, 1295 (Fed. Cir. 2002).

The step of stopping the obtaining of any thermal images of a formed sample is not "necessarily present" in the device of Shepard. Quite the contrary, the abstract of Shepard discloses the use of an infrared camera to capture multiple, spatially different images of a sample that has been heated and allowed to cool to equilibrium temperature. This indicates that a thermal image is taken after a sample is formed and allowed to cool.

In the present application, the pool of material cools sufficiently to solidify and become the weld well before the first and second plastic pieces return to thermal equilibrium. Thus, since there are no thermal images obtained after the weld is formed, there are no thermal images taken from the point at which the weld forms until the pieces return to thermal equilibrium. This is clearly in contrast to Shepard, where thermal images are obtained over the range of time during which the sample

temperature returns to equilibrium (Paragraph 63). Accordingly, Shepard does not teach stopping the obtaining of thermal images of a weld after the weld is formed and, therefore, does not cure the deficiencies of Messler and Juret. Since the combination of Messler, Juret and Shepard does not teach the subject matter of claim 33, it is respectfully submitted that claim 33 is patentable over the art of record and is therefore allowable.

Claim 35

Claim 35 recites that the path is a closed-curved shape, and wherein the step of heating the first and second pieces at their location of abutment to form a pool of material at the location of abutment which pool of material forms a weld between the pieces is performed by directing the laser beam around the path of the weld pool multiple times. Modifying occurs during directing of the laser beam around the path during at least one of the multiple times. None of the cited references disclose or suggest this feature. In fact, the Final Office Action and Advisory Action fail to cite any reference or even any reason to reject claim 35. Therefore, claim 35 is allowable.

Claim 13

The combination of Messler and Juret does not teach or suggest all the limitations of claim 13 because the step of directing the laser beam over the path of a weld pool multiple times is not equivalent to a plurality of short point applications of a laser beam along a path.

Claim 13 recites the step of heating first and second plastic pieces by directing a laser beam over a path of a weld pool multiple times to form a pool of material. Simultaneously with the heating step, a thermal image is obtained as a weld is being formed between the first plastic piece and the second plastic piece,

which is transmissive to the laser beam, by collecting infrared radiation within the determined range of wavelengths from the weld and the pool of material. The combination of Messler and Juret does not disclose or suggest this subject matter.

The Examiner asserts that Messler teaches a laser beam in a continuous mode and that this mode, in its broadest reasonable interpretation, constitutes a plurality of short point applications of the laser beam equivalent to heating the abutment, i.e. path, multiple times (see Advisory Action). Claim 13 does not recite that the plastic parts are heated by the laser beam by a plurality of point applications. Rather, claim 13 specifically recites directing the laser beam over the path of a weld pool multiple times. This recitation is clearly supported in the specification. In particular, it is disclosed that the beam 50 of electromagnetic energy may start in the upper, right corner of the weld pool 60 (Fig. 2) and may be moved around the generally square-shaped path in a clockwise direction multiple times (Page 11, lines 5-9). Thus, the beam 50 is directed over the same points on the path multiple times. This beam directing is not equivalent to a plurality of short applications of a beam, as the Examiner asserts.

In fact, Messler specifically teaches not directing the laser beam over the path of a weld pool multiple times. In particular, Messler specifically discloses that for the first method of Fig. 2, a laser beam 20 strikes two movable beam-deflecting mirrors 23, 24, which direct the laser beam to the workpiece 10 through a theta objective 35 to produce the weld seam 15 by simultaneous welding (Col. 4, lines 9-16). Messler specifically discloses that the laser beam 20 enters a processing head 50 and is collimated by a lens 45 in the method of Fig. 6. The beam then passes through two

mirrors 43, 44 and is bundled by a collimator 46 and focused on a well-defined area 47 of the workpiece 10 (Col. 6, lines 14-17). A melt 48 of both materials 18, 19 forms in the area of the focus 47. During movement of the workpiece 10 relative to the processing head 50, the focus moves along the workpiece, and the melt gradually undergoes solidification 49. The weld seam 15 forms in this way (Col. 6, lines 26-31). Thus, the laser beam is directed over the path, where the weld seam is formed, only once and not multiple times. The head 50 does not, for example, return to the start of the weld 15 and re-trace the same weld path to form the weld 15. Accordingly, Messler does not teach or suggest directing a laser beam over the path of a weld pool multiple times.

Juret discloses a high energy-density beam 4 from a beam generator that welds two metal plates at their joint. The beam-generator 3 is fixed to a frame member 5 that is displaceable in the direction of the plane of the joint of the metal plates 1, 2 being welded. Juret discloses that the frame member 5 moves from left to right during welding of the plates. Juret fails to disclose or suggest directing the beam 4 over a path of a weld pool multiple times and, thus, does not cure the deficiencies of Messler.

The combination of Messler and Juret further also fails to teach the step of obtaining a thermal image by collecting infrared radiation within a determined range of wavelengths from a weld and a pool of material. As noted, Messler teaches that a pyrometer 58 uses thermal radiation to image only an unsolidified weld melt 48 and a detector 55 uses inspection radiation 30 to image only a solidified weld seam 15. Thus, Messler does not teach obtaining a thermal image by collecting infrared

radiation within a determined range of wavelengths from a weld and a pool of material.

Juret does not cure the deficiencies of Messler, as Juret teaches thermal imaging only of a fused metal zone and not obtaining a thermal image of a weld and a pool of material, as recited in claim 13. For these reasons, the combination of Messler and Juret does not teach the subject matter of claim 13. Accordingly, it is respectfully submitted that claim 13 is patentable over the combination of Messler and Juret and is therefore allowable.

Claim 24 depends from claim 13 and is allowable for at least the same reasons as claim 13 and for the specific limitations recited therein.

Claim 14

The combination of Messler and Juret does not teach or suggest all the limitations of claim 14.

Claim 14 recites the step of obtaining a thermal image that includes, in its entirety, the weld pool that results in a weld. As noted, the combination of Messler and Juret does not teach this subject matter. Thus, it is respectfully submitted that claim 14 is patentable over the combination of Messler and Juret and is therefore allowable.

Claims 15-21 depend from claim 14 and are allowable for at least the same reasons as claim 14 and for the specific limitations recited therein.

Claim 34

The combination of Messler and Juret does not teach or suggest all the limitations of claim 34, and Shepard does not cure the deficiencies of Messler and Juret because the step of stopping the obtaining of any thermal images of a formed sample is not “necessarily present” in Shepard.

Claim 34 recites the step of obtaining a plurality of thermal images as the weld is being formed and stopping the obtaining of any thermal images of the weld after the weld is formed. The Examiner acknowledges that Messler and Juret do not teach obtaining a plurality of images and stopping the obtaining of any thermal images of a weld after the weld is formed. The Examiner asserts, however, that Shepard cures the deficiencies of Messler and Juret. As noted, the combination of Messler, Juret and Shepard does not teach the step of obtaining a plurality of thermal images as the weld is being formed and stopping the obtaining of any thermal images of the weld after the weld is formed. Accordingly, it is respectfully submitted that claim 34 is patentable over the combination of Messler, Juret and Shepard and is therefore allowable.

Claim 36

Claim 36 recites that the path is a closed-curved shape, and wherein the step of heating the first and second plastic pieces at their location of abutment is performed by directing the laser beam around the path of a weld pool multiple times to form a pool of material at their location of abutment which pool of material forms a weld between the pieces. None of the cited references disclose or suggest this feature. In fact, the Final Office Action and Advisory Action fail to cite any reference or even any reason to reject claim 36. Therefore, claim 36 is allowable.

VIII. APPENDIX

Appendix A attached contains a copy of the claims on appeal.

IX. EVIDENCE APPENDIX


The attached Evidence Appendix contains no evidence.

X. RELATED PROCEEDINGS APPENDIX

The attached Related Proceedings Appendix contains no related proceedings.

Please charge any deficiency or credit any overpayment in the fees for this amendment to our Deposit Account No. 20-0090.

Respectfully submitted,


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APPENDIX A

Claim 1 (Previously Presented): A method for welding and monitoring the quality of a laser weld being formed between first and second pieces of plastic material comprising the steps of:

positioning the first and second pieces to abut each other, the second plastic piece being transmissive to a laser beam;

heating the first and second pieces at their location of abutment by directing the laser beam to form a pool of material at the location of abutment which pool of material forms a weld between the pieces;

simultaneous with said heating step, obtaining a thermal image as the weld is being formed by collecting infrared radiation passing through the second piece of material from the weld and the pool of material;

analyzing the obtained thermal image for characteristics indicative of an acceptable weld being formed;

providing a feedback signal to a weld controller in response to determining that a characteristic fails to meet an associated criterion; and

modifying the heating in response to said feedback signal.

Claim 2 (Original): The method of claim 1 wherein the step of obtaining a thermal image of the weld being formed further includes the step of:

obtaining a thermal image that includes, in its entirety, a weld pool that results in the weld.

Claim 3 (Original): The method of claim 2 wherein the step of obtaining a thermal image that includes the weld pool in its entirety further includes the step of:

- positioning an infrared detector that is configured to detect infrared radiation having a wavelength that passes through the second piece of material on a side of the second piece of material opposite the first piece of material and in a location in which the weld pool in its entirety is within a field of view of the infrared detector.

Claim 4 (Original): The method of claim 2 wherein the step of analyzing the obtained thermal image for characteristics indicative of a properly formed weld includes the steps of:

- determining a temperature of each portion of the weld pool; and
- comparing the determined temperature of each portion of the weld pool with a threshold temperature range.

Claim 5 (Original): The method of claim 4 wherein the step of comparing the determined temperature of each portion of the weld pool with a threshold temperature range further includes the steps of:

- determining a time at which the thermal image was obtained; and
- comparing the determined temperature of each portion of the weld pool with a threshold temperature range that is associated with the determined time to determine whether the determined temperatures are within the associated threshold temperature range.

Claim 6 (Original): The method of claim 5 further including the step of:
providing a feedback signal to a weld controller in response to
determining that a determined temperature is outside of the associated threshold
temperature range.

Claim 7 (Original): The method of claim 2 wherein the step of analyzing the
obtained thermal image for characteristics indicative of a properly formed weld
includes the steps of:

determining a width of the weld pool at all locations along a path of the
weld pool; and

comparing the determined widths to a threshold width range to
determine whether the determined widths are within the threshold width range.

Claim 8 (Original): The method of claim 7 further including the step of:
providing a feedback signal to a weld controller in response to
determining that a determined width is outside of the threshold width range.

Claims 9-11 (Canceled)

Claim 12 (Previously Presented): The method of claim 1 further including
the step of:

providing an alarm signal to an alarm device in response to
determining that a characteristic fails to meet the associated criterion.

Claim 13 (Previously Presented): A method for welding and monitoring the quality of a laser weld being formed between first and second pieces of plastic material comprising the steps of:

positioning the first and second plastic pieces to abut each other, the second plastic piece being transmissive to a laser beam;

heating the first and second plastic pieces at their location of abutment by directing the laser beam over the path of a weld pool multiple times to form a pool of material at their location of abutment which pool of material forms a weld between the pieces;

determining a range of wavelengths of infrared radiation that will pass through the second piece of material;

positioning an infrared detector that is configured to detect infrared radiation within the determined range of wavelengths on a side of the second piece of material opposite the first piece of material;

simultaneous with said heating step, obtaining a thermal image as the weld is being formed between the first and second pieces of material by collecting infrared radiation within the determined range of wavelengths from the weld and the pool of material; and

analyzing the obtained thermal image for characteristics indicative of an acceptable weld being formed.

Claim 14 (Previously Presented): The method of claim 13 wherein the step of obtaining a thermal image of the weld being formed further includes the step of:

obtaining a thermal image that includes, in its entirety, the weld pool that results in the weld.

Claim 15 (Original): The method of claim 14 wherein the step of analyzing the obtained thermal image for characteristics indicative of a properly formed weld includes the steps of:

determining a temperature of each portion of the weld pool; and

comparing the determined temperature of each portion of the weld pool with a threshold temperature range.

Claim 16 (Original): The method of claim 15 wherein the step of comparing the determined temperature of each portion of the weld pool with a threshold temperature range further includes the steps of:

determining a time at which the thermal image was obtained; and

comparing the determined temperature of each portion of the weld pool with a threshold temperature range that is associated with the determined time to determine whether the determined temperatures are within the associated threshold temperature range.

Claim 17 (Original): The method of claim 16 further including the step of:
providing a feedback signal to a weld controller in response to determining that a determined temperature is outside of the associated threshold temperature range.

Claim 18 (Previously Presented): The method of claim 14 wherein the step of analyzing the obtained thermal image for characteristics indicative of a properly formed weld includes the steps of:

determining a width of the weld pool at all locations along the path of the weld pool; and

comparing the determined widths to a threshold width range to determine whether the determined widths are within the threshold width range.

Claim 19 (Original): The method of claim 18 further including the step of:

providing a feedback signal to a weld controller in response to determining that a determined width is outside of the threshold width range.

Claim 20 (Original): The method of claim 14 wherein the step of analyzing the obtained thermal image for characteristics indicative of a properly formed weld includes the step of:

analyzing the weld pool in its entirety for indications of a void in the weld pool.

Claim 21 (Original): The method of claim 20 further including the step of:

providing a feedback signal to a weld controller in response to determining that a void exists in the weld pool.

Claims 22-23 (Cancelled)

Claim 24 (Previously Presented): The method of claim 13 wherein the step of obtaining the thermal image of the weld being formed includes the step of filtering the infrared radiation to block out the electromagnetic energy having a first wavelength that is used in heating the first and second pieces at their location of abutment to form a pool of material and a weld between the first and second pieces.

Claim 25 (Previously Presented): The method of claim 1 wherein the step of heating the first and second pieces at their location of abutment to form a pool of material at the location of abutment which pool of material forms a weld between the pieces is performed by directing the laser beam over the path of the weld pool multiple times; and said modifying occurs during directing of the laser beam over the path during at least one of said multiple times.

Claim 26 (Previously Presented): The method of claim 1 wherein the first piece absorbs the heat from the laser beam and heats the second piece.

Claim 27 (Previously Presented): The method of claim 25 wherein said modifying is performed by moving the laser beam over the path at different speeds.

Claim 28 (Previously Presented): The method of claim 1 wherein the step of obtaining the thermal image as the weld is being formed does not include collecting the wavelength of the laser beam used to heat the first and second pieces of plastic material at their location of abutment.

Claim 29 (Previously Presented): The method of claim 1 wherein said laser beam is reflected by a reflective device onto the first and second pieces at their location of abutment.

Claim 30 (Previously Presented): The method of claim 29 including the step of positioning an infrared camera having a field of view to obtain the thermal image, wherein the reflective device is outside the field of view of the infrared camera.

Claim 31 (Previously Presented): The method of claim 1, including the step of, simultaneous with said heating step, obtaining another thermal image as the weld is being formed by collecting infrared radiation passing through the second piece of material from the weld and the pool of material, each of the thermal image and the other thermal image including, in its entirety, a weld pool that results in the weld.

Claim 32 (Previously Presented): The method of claim 31 including the steps of analyzing the obtained other thermal image for characteristics indicative of an acceptable weld being formed;

providing another feedback signal to a weld controller in response to determining that a characteristic from analyzing the other thermal image fails to meet an associated criterion; and

modifying the heating in response to the other feedback signal.

Claim 33 (Previously Presented): The method of claim 1, including the steps of, simultaneous with said heating step, continuously obtaining a plurality of thermal images as the weld is being formed by collecting infrared radiation passing through the second piece of material from the weld and the pool of material, each of said thermal images including, in its entirety, a weld pool that results in the weld; analyzing the obtained thermal image for characteristics indicative of an acceptable weld being formed; determining that weld is formed; and stopping the obtaining of any thermal images of the weld after the weld is formed.

Claim 34 (Previously Presented): The method of claim 13, including the steps of, simultaneous with said heating step, continuously obtaining a plurality of thermal images as the weld is being formed by collecting infrared radiation passing through the second piece of material from the weld and the pool of material, each of said thermal images including, in its entirety, a weld pool that results in the weld; analyzing the obtained thermal image for characteristics indicative of an acceptable weld being formed; determining that weld is formed; and stopping the obtaining of any thermal images of the weld after the weld is formed.

Claim 35 (Previously Presented): The method of claim 25, wherein the path is a closed-curved shape, and wherein the step of heating the first and second pieces at their location of abutment to form a pool of material at the location of abutment which pool of material forms a weld between the pieces is performed by directing the laser beam around the path of the weld pool multiple times; and said

modifying occurs during directing of the laser beam around the path during at least one of said multiple times.

Claim 36 (Previously Presented): The method of claim 13, wherein the path is a closed-curved shape, and wherein the step of heating the first and second plastic pieces at their location of abutment is performed by directing the laser beam around the path of a weld pool multiple times to form a pool of material at their location of abutment which pool of material forms a weld between the pieces.

IX. EVIDENCE APPENDIX

None.

X. RELATED PROCEEDINGS APPENDIX

None.